Selection of Accuracy Assessment Areas-

Shallow-water Benthic Habitat Mapping of the Republic of Palau

U.S. Department of Commerce National Oceanic and Atmospheric Administration
National Ocean Service
National Center for Coastal Ocean Science

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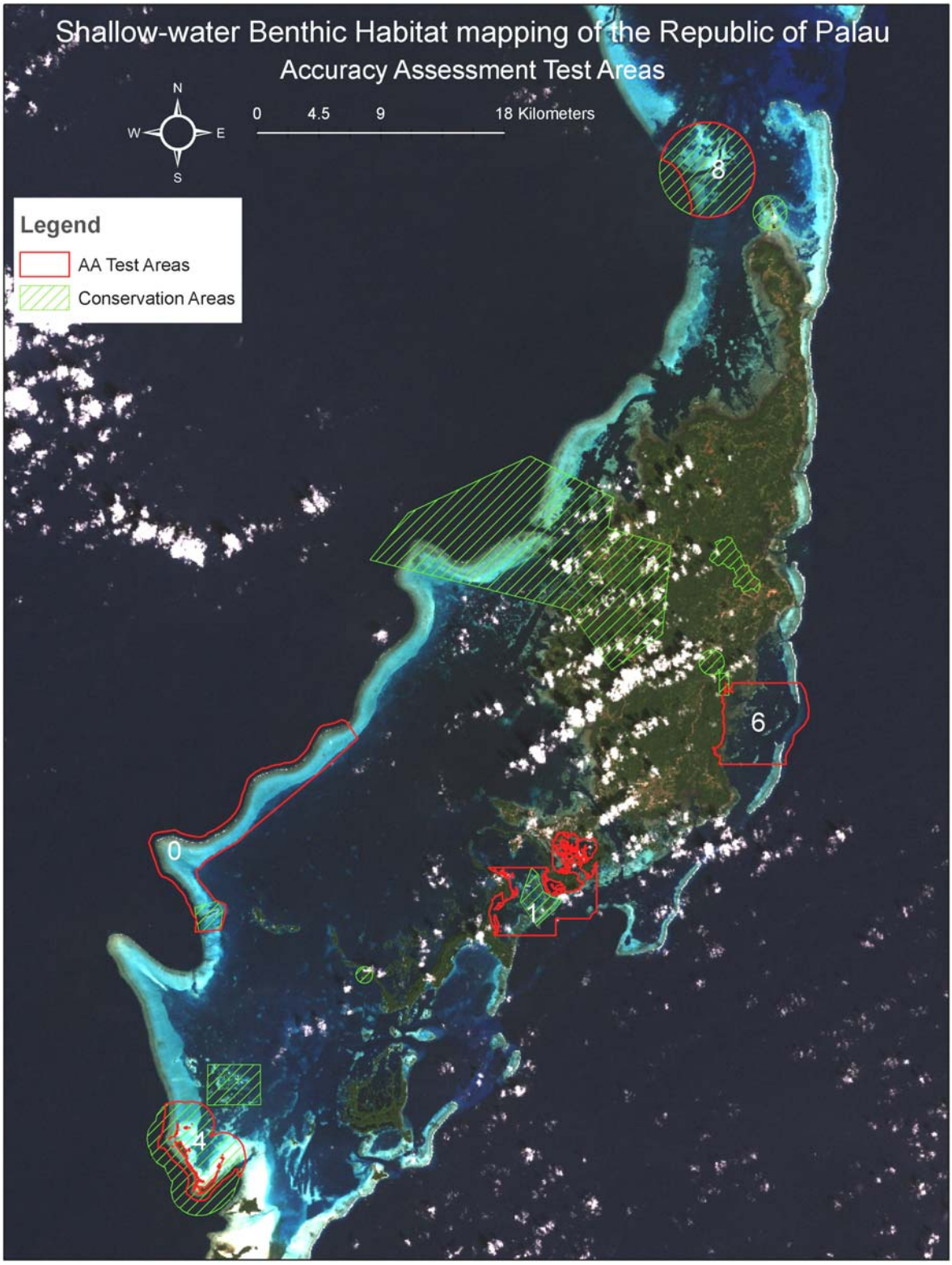

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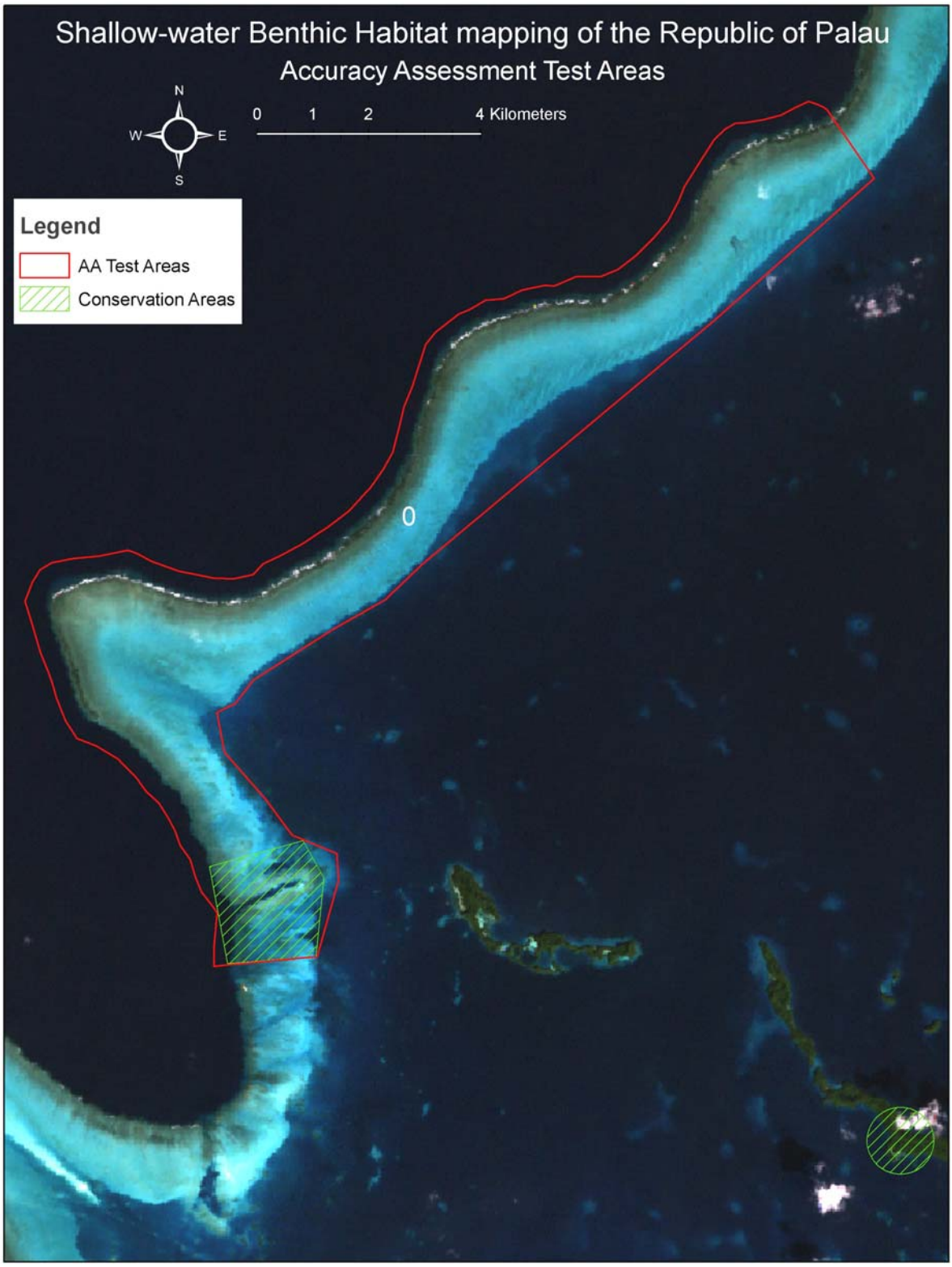

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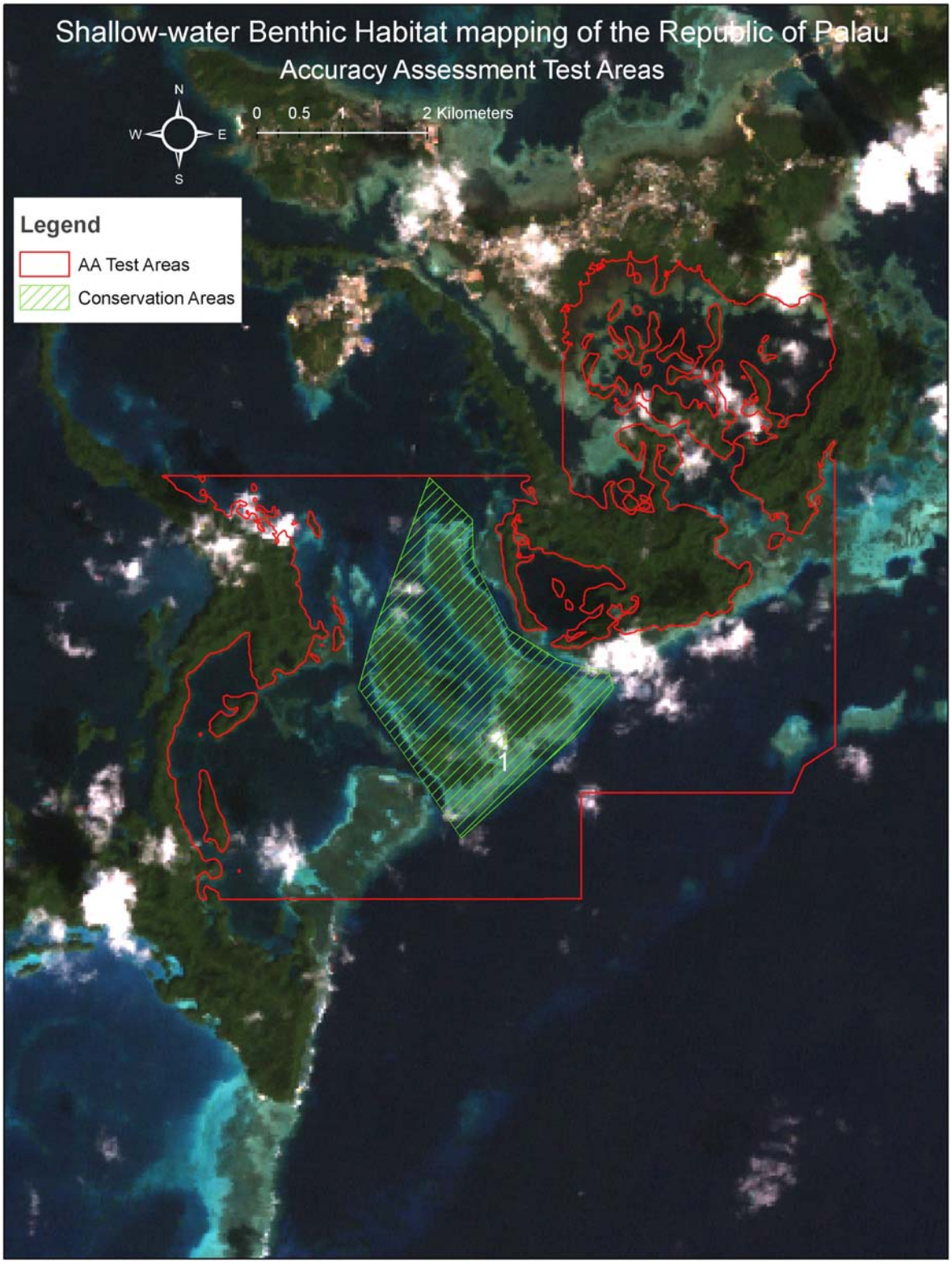

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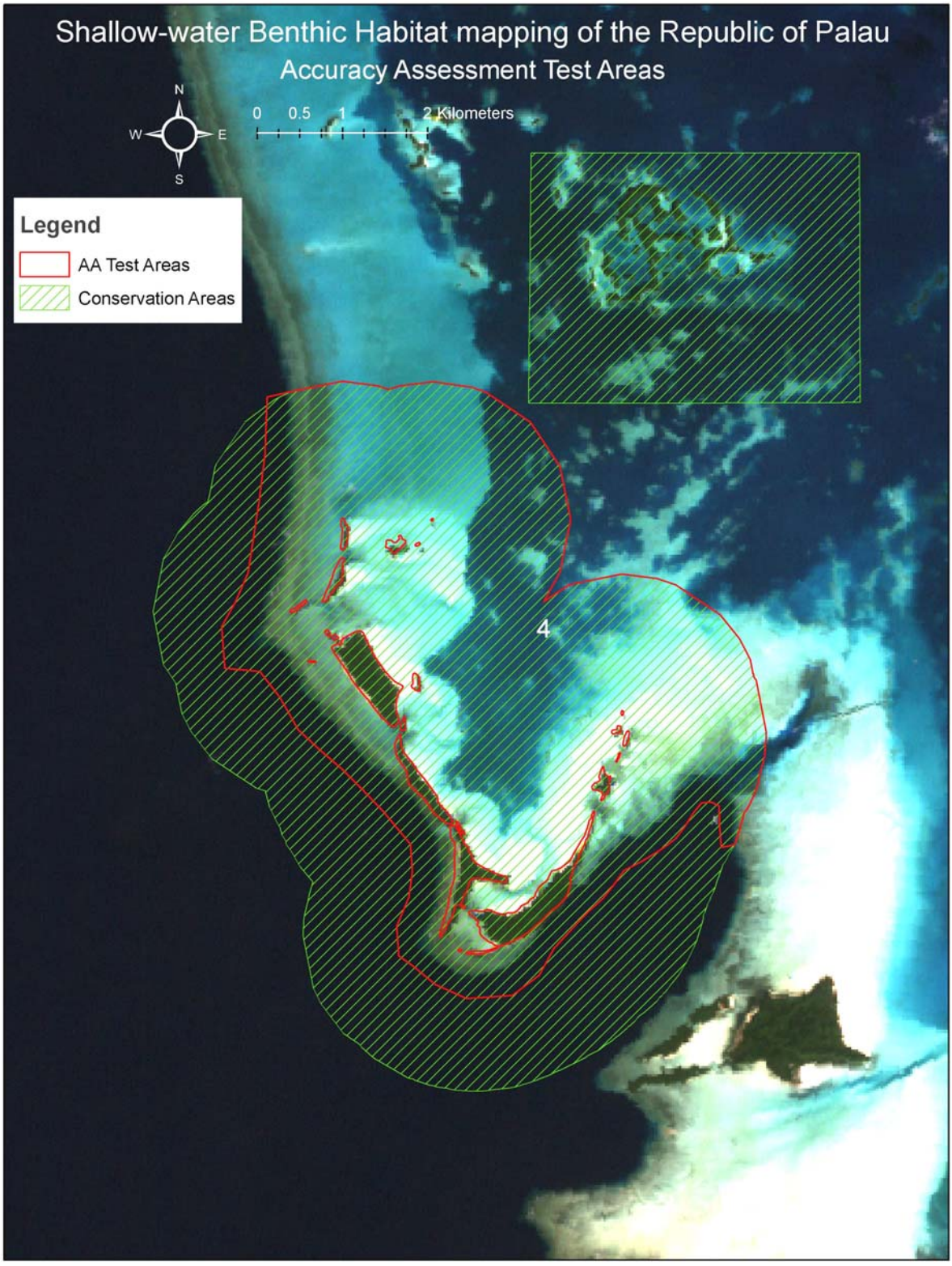

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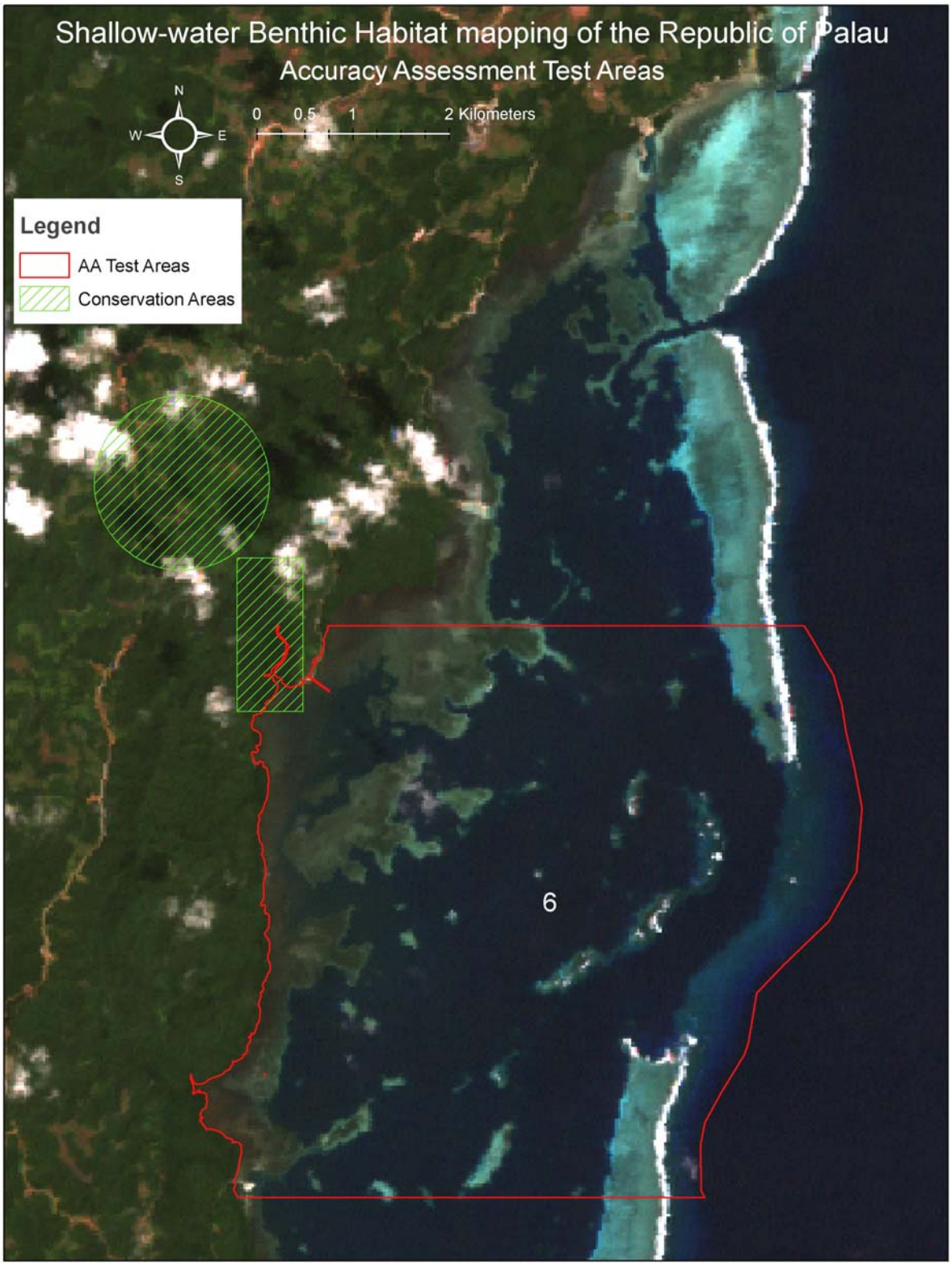

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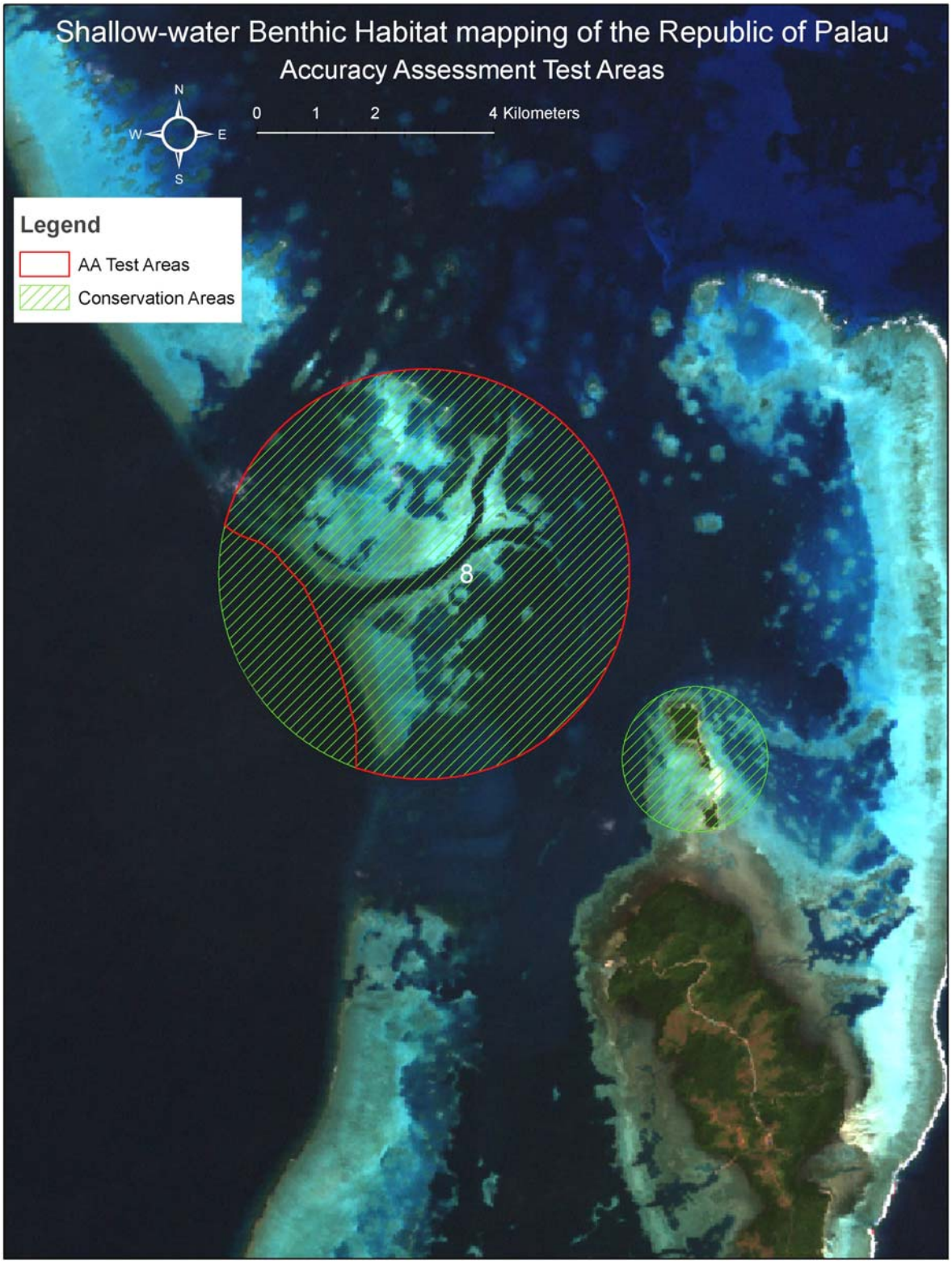


Accuracy Assessment Area 8

Assessment of Classification Accuracy

The NOAA Coral Mapping Program has developed a rigorous series of protocols to generate geospatial benthic habitat mapping products of the highest integrity. An initial requirement of the methodology is to identify locations within the mapping regions which are suitable for assessing the thematic accuracy of the geospatial product. At the Republic of Palau mapping kick-off meeting conducted April 2005, the Palauan user community was prompted by NOAA to provide input on the selection of suitable accuracy assessment areas.

NOAA articulated several criteria to be used in the identification of accuracy assessment areas:

1) total area should be less then 150 km^2,
2) areas should represent the full diversity of geomorphological structure and biological structure classes;

and

3) areas should represent the full diversity of possible environmental conditions (e.g. exposure, depth range, sheltered embayment).

Based on these criteria, the Palauan community provided a set of ten possible accuracy assessment areas each approximately 25 km^2 to NOAA on May 25, 2005. Many of the areas selected coincided with pre-existing conservation areas for Palau. NOAA and Analytical Labs of Hawaii reviewed these areas to develop a matrix in order to determine the relevancy, usability, and priority of the provided areas. The selection criteria developed by NOAA and ALH included: a measure of the diversity of the detailed structure, cover and zone (1-Low, 2 –Medium, 3-High), exposure, depth range, quality of the IKONOS imagery, mappable conservation area, and mappable shallow water benthic habitat area.

Summary of Assessment:

AA 0: This area had a moderately high diversity of structure/cover types, and the only area with the highest density of coralline algae. AA Area 0 also had a small percentage overlap with a conservation area.

Action – Use AA Area 0 with modification. Alter the southern boundary to abut the conservation area and extend the boundary around the fringing reef to the northeast to include regions of significant macrolagae. Total revised area 49 km^2.

AA 1/5: These two areas were in-close proximity to each other. AA Area 1 had a high diversity of cover and structure type. Important cover types present include Aggregate reef, Aggregated patch reef, Scattered coral/rock, and pavement. Area 5 had a low diversity of cover and structure types, however the region contains an important representation of sheltered embayment conditions.

Action – Combine AA 1/5 and use with modification. Alter the boundary to exclude areas of least interest or represented in other AA areas. Include the entire conservation area. Total revised area 33 km^2.

AA 2: This area had a low diversity of structure/cover types and poor IKONOS imagery coverage.

Action – Not to be included.

AA 3/4: These two areas were in-close proximity to each other. Diversity of cover and structure type, was unknown at this time, but anticipated to be high.

Action – Combine AA 1/5 and use with modification. Alter the boundary to include a greater

coverage of the conservation area. Also extend the shoreward boundary to include a greater percentage of mappable area. Total revised area 26 km^2.

AA 6: This area had a low diversity of cover and structure type. However, it is the only location provided with a high density of mangroves present.

Action – Use AA 6 with significant modification. Extend the boundary south and east to include areas of high exposure on the reef flat and pavement with sand channels along the submerged reef feature. Total revised area 33 km^2.

AA 7: This area had limited utility once AA Area 6 was modified to include high exposure areas.

Action – Not to be included.

AA 8: This area had a moderately high diversity of structure/cover types, and the including individual patch reef, scattered coral and rock, pavement, and coralline algae. This AA also had a high percentage of overlap with a conservation area.

Action – Use AA Area 8 with modification. Expand the boundary to include the full mappable extent of the conservation area. Total revised area 33 km^2.

AA 9: The cover and structure types in this area were sufficiently sampled in other AA areas. Logistical problems associated with remoteness of the area.

Action – Not to be included.

Summary

Five Accuracy Assessment Areas – AA 0, AA 1, AA 4, AA 6, AA 8
Total AA Area 174 km^2
Total AA Area contained within conservation areas 164 km^2

Case Study - Benthic Habitats of the U.S. Pacific Territories

The following material is included to provide context as to the NOAA accuracy assessment procedures, scientific rational and summary results.

Assessment of Classification Accuracy

Introduction

The quality of the habitat information derived from remotely sensed data is determined by the quantitative process of accuracy assessment. The purpose of accuracy assessment is to identify and quantify errors in the maps by comparing the attributes of the map versus reference data at various sites. It is important that the mapmaker know how reliably a given habitat can be classified. This parameter is called "producers accuracy". The users of a map product want to know what percentage of the polygons of a particular class are correctly attributed. This parameter is called "users accuracy". Furthermore, remotely sensed imagery that may be suitable for mapping coral reef habitats can be acquired from a wide variety of platforms and imaging systems, each having it's own strengths and limitations. It is important to identify the technical merits of each, one measure of which is the thematic accuracy of the map products.

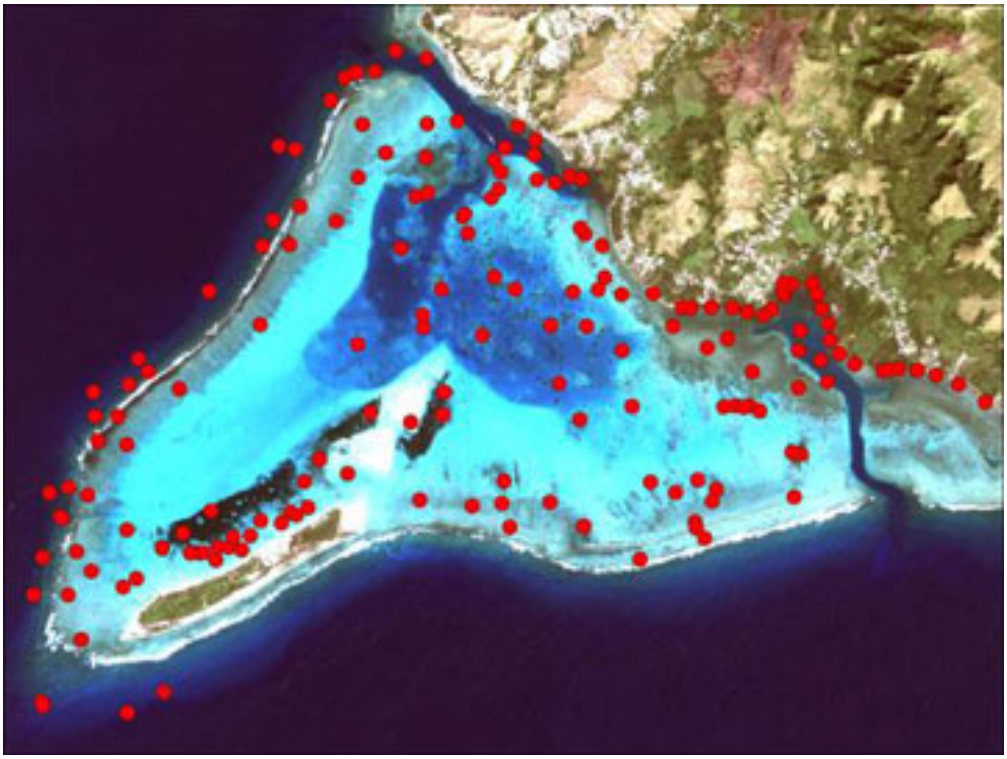
To determine the overall accuracy of the mapped product, GIS data prepared by visually interpreting IKONOS satellite imagery was assessed for accuracy using conventional methodologies. It was proposed that specific areas being mapped be used as test areas for this work. A statistically robust data set composed of random field habitat observations were collected within the test areas to assess the accuracy of the mapped product. These areas were chosen based on input from the local marine biologists and coral reef managers. These groups provided advice on the location of the most diverse benthic communities and also areas of particular importance based on management strategies and marine protected areas. Thus, it was the goal of this team to collect accuracy assessment field data representing as many of the habitats that occur in these regions as possible.

The thematic accuracy of all mapped products was determined at the most general and detailed levels of the classification scheme including both the biological cover type and geomorphological structure. Sixteen coral reef test areas were selected based on the diversity of the habitat types and to assure that all benthic habitats throughout the U.S. Pacific Territories were represented. The accuracy of all maps is, therefore, considered a conservative representation of the thematic accuracy of the habitat maps prepared using the same methods for imagery collected throughout the remainder of the U.S. Pacific Territories.

Evaluating Thematic Accuracy

Thematic Accuracy in American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands

An accuracy assessment system was designed and executed to quantify the thematic accuracy of the maps generated at all levels of the classification scheme. Statistical analysis methods have been applied that have been developed by other researchers (Hudson and Ramm 1987, Congalton 1991, Rosenfield et al. 1982). In this work, 20 to 30 field habitat observations were completed per detailed structure as well as detailed biological cover type (see Figure). The accuracy assessment is prepared from a matrix that compares the attribute assigned to a polygon that was generated from the interpretation of the image with that of the determination from field observation.



Five test areas for American Samoa and eleven test areas for the Marianas Archipelago were established to determine the thematic accuracy of the benthic habitat maps prepared from IKONOS satellite imagery. The test areas for American Samoa included Pala Lagoon, Fagatele Bay, Fagaitua Bay, the Manu'a Islands and Tafeu. The test areas for the Marianas Archipelago included Piti Bay and Cocos Lagoon, Guam; Saipan Lagoon and Lau Lau Bay, Saipan; South Beach, Tinian; west and southeast sides of Rota; the west side of Sarigan; and the entire islands of Pagan, Agrihan, and Maug.

Benthic habitat maps from these areas were generated from IKONOS satellite imagery collected at 4 meter resolution and pansharpened to 1 meter resolution. All image interpretation and digitizing was conducted by a single NOAA contractor. The field habitat characterization data collection methods for thematic accuracy assessment differed little from the data collected for ground validation. The primary distinction between the two data sets was the method of selection of the field points. Where as the assessment sites for ground validation were selected to specifically investigate habitat types and gradients of spectral signatures in the imagery, a random stratified sampling method was implemented to select field sites to test map accuracy (Congalton 1991).

Subsequent to completion of the second draft coral reef habitat maps, waypoints were generated using a stratified random sampling scheme. Twenty to thirty accuracy assessment waypoints were collected per test area for each detailed structure and detailed cover class encountered. Waypoint files were generated from these points and all waypoints that could be safely accessed were navigated to using a Trimble Geo Explorer 3 GPS data logger (see Figure). Upon arriving at the waypoint, a weighted meter line was dropped, a buoy fastened and site and habitat specific data collection was undertaken. After deployment of the buoy, 100 GPS positions were collected at one-second intervals and were averaged to generate a single position.

Three benthic habitat assessments were conducted. A point assessment was conducted by surveying the one square meter area around the point where the weight dropped. Two area assessments were conducted in an area of a seven-meter radius around the weight. The first assessment identified the most common habitat type within

the area and the second identified the second most common habitat type with in the area. The depth of the site was recorded using a hand held depth sounder. Benthic habitat assessments were made using a glass bottom look box, free diving or observing from the surface. All diving was conducted by breath holding or snorkeling on the surface. In areas where waves and sea conditions were prohibitive to safely accessing the waypoint by boat the GPS was placed in a watertight box and swam to the survey point.

Data including but not limited to site ID, depth, most common habitat, zone and assessment method were recorded using the GPS data logger equipped with a custom data dictionary designed to meet the specifications of the Coral Reef Habitat Classification Scheme. At the end of each field day, the data were downloaded, differentially corrected to the closest CORS station and seamlessly converted to ArcView GIS format. All hand written descriptions were entered in waterproof notebooks and transferred to the GIS by hand. A total of 1,720 benthic habitat characterizations were completed in all sixteen test areas combined, 613 characterization points for American Samoa and 1107 points for the Marianas Archipelago.

To maintain objectivity in the analysis of accuracy, an independent team conducted this work. The Coral Reef Assessment and Monitoring Program (CRAMP) biologists from the Hawaii Institute of Marine Biology from the University of Hawaii at Manoa made the official judgments. The accuracy assessment point theme and the benthic habitat polygon themes were overlaid on the imagery in the GIS. The GIS was queried to select all points within the polygons that matched the polygon habitat type. These were set aside as correct calls. The mismatched pairs were closely examined.

The classification errors that occurred between the MMU and size of accuracy assessment areas were accounted for in this analysis. A map classification was not considered incorrect in a case where a seven meter radius field assessment fell on a habitat feature in the field that was smaller than 1 acre. For example, if a field assessment fell on a small patch reef surrounded by sand that was less than the MMU and thus was not mapped, the point was excluded from the accuracy assessment report. Points that fell close to polygon boundaries were all included as it was assumed that the probability of error contributing to false negatives would be equal to that for false positives. The habitat type for the portions of the test area that were not interpretable due to cloud cover, glint or water quality were classified as "unknown". The accuracy assessment points that fell within polygons with the habitat type of "unknown" were not included in the accuracy analysis.

Results of Overall Accuracy Assessment of Benthic Habitat Map Products

Thematic accuracy of the benthic habitat maps was determined using the aforementioned methods. The mapped habitat type was compared with that of the actual habitat type from field observation. The data is organized into columns representing the field habitat assessment and the rows organized into mapped habitat type. The correct class for each of the incorrect attributes was recorded and included in a comprehensive matrix at the most detailed level of the classification scheme. Four of these detailed matrices were generated, one each for biological cover and geomorphological structure in American Samoa and the Marianas Archipelago. Error matrices were prepared at the detailed and general levels to identify patterns of confusion in the interpretation of the signatures in the imagery. This information was incorporated into ongoing work to improve the accuracy of mapped product. A complete description of these results can be found in the final project report, Project Completion Report: Mapping of Benthic Habitats for U.S. Pacific Territories.

Traditionally, the data is organized into columns that represent the field habitat validation data and the rows are organized into the interpretation of the images. The overall accuracy is typically measured by dividing the total correct determinations by the total number of assessments. This result only incorporates the major diagonal of the table and excludes the omission and commission errors whereas the Tau analysis indirectly incorporates the off-diagonal elements as a product of the row and column marginals. Furthermore, the Tau analysis compensates for unequal probabilities of groups or for differences in numbers of groups (Ma and Redmond 1995). This assessment lends itself to statistical analysis wherein the photointerpreter's determination is assigned a probability that it occurred at random (see Table).

Table 1: Summary of benthic habitat map thematic accuracy.

American Samoa		
Map Category	**Overall Accuracy**	**Tau**
Major Structure	98.0%	0.97
Detailed Structure	84.0%	0.83
Major Cover	87.6%	0.86
Detailed Cover	77.3%	0.76
Marianas Archipelago		
Map Category	**Overall Accuracy**	**Tau**
Major Structure	98.7%	0.98
Detailed Structure	92.6%	0.92
Major Cover	87.8%	0.86
Detailed Cover	80.9%	0.80